ChE 354 Unit Operations I | **Dept. of Chemical Engineering**
Michael E. Poehl | **University of Texas at Austin**
Fall 2010 | **Unique Numbers – 14660 & 14665**

Instructor: Professor Michael E. Poehl
CPE 5.404 hornzup@sbcglobal.net
Phone – 512 – 809 - 3030 cell
Office Hours : Mon 11:00 am-Noon, Wed 1:00 pm-2:00 pm-or by appointment

Teaching Assistant: Nichoalas Cristea *Hours* : Tu & Th 12:30 to 1:30 pm – or by appointment
CPE 4.446 e-mail - ncristea1985@yahoo.com

Class Hours:

MWF	Noon - 12:00 pm	CPE 2.218
W	3:00 pm - 4:00 pm	CPE 2.218 Unique Number 14660
W	4:00 pm - 5:00 pm	CPE 2.218 Unique Number 14665

Prerequisites: ChE 348 and ChE 353 with at least a C in Each

Text: "Unit Operations of Chemical Engineering", 7th Ed.
McCabe, Smith, and Harriott, New York, McGraw-Hill, 2004 ("MSH")

Grading System:

- Homework 15 %
- Pop Quizzes / Attendance 5 %
- Exams (3) 45 %
- Final Exam 30 %
- Effort / Participation up to 5 %

Final course grades will be assigned according to the "gap system". In other words, the final grade distribution for all students will be plotted and cut-offs for grades will be determined based on breaks in the distribution. Thus, a student's performance in the class is measured relative to the performance of the remainder of the class.

Course Overview:

1. Static fluid phenomena
2. Flow of incompressible fluids
3. Flow of compressible fluids
4. Flow past objects
5. Conductive heat transfer
6. Convective heat transfer
7. Heat transfer equipment design
8. Radiation

Goals: The course covers analysis and design of heat exchangers, fluid flow equipment and some interphase contacting devices. This course serves to integrate the fundamental concepts learned in ChE 353 with practical chemical engineering problems and industrial applications. Key objectives of this course are to enhance problem definition and problem solving skills of the student, and to improve the student's ability to make calculations and obtain correct final answers.

Knowledge, Abilities, and Skills Students Should Have Entering This Course:

1. The catalog lists ChE 348 and ChE 353 as prerequisites. The course relies heavily on the mass, momentum, heat and energy balance equations developed in 353. Some computer programming experience from ChE 210/348 is valuable.
2. Basic mathematical and computer programming skills.
3. Ability to perform macroscopic mass and energy balances under steady state and dynamic conditions (from ChE 353).
4. Familiarity with equations of state, particularly the ideal gas law (from ChE 317).
5. Familiarity with concepts of enthalpy, work, heat and other thermodynamic quantities (from ChE 317).
6. Mastery of the fundamentals of transport phenomena including familiarity with the equations used to describe momentum and heat transfer, an understanding of dimensionless groups, and the ability to derive momentum and heat balance equations (from ChE 353).

Knowledge, Abilities and Skills Students Should Gain in this Course:

1. Familiarity with the methods used to analyze and design fluid processing equipment, heat exchangers and interphase contacting devices for incompressible fluids.
2. Recognition of the challenges of designing processing equipment for compressible fluids.
3. The ability to analyze and size piping networks, valves, pumps, compressors and flow meters.
4. The ability to determine heat transfer coefficients and the ability to size heat exchangers.
5. The ability to apply the principles of transport phenomena to the analysis of a wide range of processing equipment including evaporators, fluidized beds, and chemical reactors.

These 5 topics lead to your ability to meet the following ***ABET criteria*** for accreditation for the Chemical Engineering Department at the University of Texas at Austin:

c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

Impact on Subsequent Courses in Curriculum:

The material taught in ChE 354 will be used extensively in the Plant Design course(ChE 473 K) and in the unit operations lab. (ChE 264). The material will also be of use in the reactor design course (ChE 372) when topics such as packed and fluidized bed reactors are discussed.

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ABET Undergraduate Program Outcomes

The objective of the chemical engineering degree program is to prepare students for professional practice after they earn the bachelor's degree or an advanced degree. Chemical engineering graduates from the University of Texas at Austin are expected to be able to:

1. Successfully apply fundamentals of science and engineering to solve problems of analysis and design of components, systems, and processes important in chemical engineering practice and research.
2. Demonstrate interpersonal skills required to lead and/or participate effectively in interdisciplinary projects.
3. Recognize the importance of life-long learning in meeting professional and personal goals, so they can be successful in their chosen profession, including graduate school.
4. Exhibit effectiveness in communication skills.
5. Articulate and practice professional, ethical, environmental and societal responsibilities, and value different global and cultural perspectives.

Contributions of this course to meeting the Chemical Engineering Department Program Outcomes :

Ethics: For each homework and test, the honest, independent evaluation of data is stressed. Commitment to your study group will emphasize analysis of data, and problem solving approach.

Design and Analysis: Students are required to design various basic engineering systems, and understand the overall design approach. The teaching assistant will provide detailed analytical approach to solution.

Teamwork: Teamwork is emphasized by discussing not only the planning of work prior to coming to class in study groups, but also the necessity for each team member to participate fully and competently in discussion sessions.

Relationship to all ABET program outcomes for Chemical Engineering:

ABET Criteria a-k Outcomes

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Format & Learning Activities:

- The textbook and supplemental notes provide overall excellent coverage of the application of momentum, heat and mass transfer. These readings are intended to provide you with some theoretical coverage of the field, but will typically emphasize the practical application of unit operation principles.
- Lectures will complement readings from your textbook and class handouts. In general, lectures will be interactive, combining in-class discussions with small group problem solving exercises, chalk board problem analyses, etc. Open-ended questions, similar to problems you may encounter in your later engineering practice, will provide you with opportunities to enhance your problem formulation and problem solving skills. Videos on how certain pieces of equipment function and a field trip to the UT power plant will provide you with the ability to identify pieces of equipment and will also help you to link the theory with the physical.
- Recitation sections will be overseen by the TA and/or the Professor and will focus on the solution of additional relevant problems. In some cases, we will cover difficult homework problems and go through exam solutions during recitation. In all cases, an emphasis will be placed on how a problem is approached and why a particular approach is selected.
- Regular homework assignments on the technical material will be given to provide practice at applying the concepts covered in lecture. Group discussion of the homework (but not copying) is encouraged. However, it is important for exams that each student know how to independently work the assigned problems on his/her own.
- Quizzes will be given in-class at random times throughout the semester and are designed to emphasize lecture and homework concepts.
- Three exams and a final will test both retention of concepts and facts, and the ability to apply problem-solving skills. Material tested will be extracted from the readings, homework, lectures, projects, and recitations.

Performance Feedback:

Feedback on your performance throughout the semester is a key component to the learning process. In addition to feedback on homework, quizzes, and exams through solution sets, comments and grades, you will receive immediate input through in-class problem-solving and group activities. Feedback will also be actively encouraged through visits during hours or by appointment. However, I encourage you to attempt all problems on your own prior to seeking additional help.

Course Policies:

Attendance -- Attendance at lectures and recitation sessions, although not mandatory, is important for your mastery of the subject matter.

Homework & Projects --

Homework and projects must be received at the beginning of the class period in which they are due.

Homework must follow the guidelines from ChE 317: engineering paper must be used, problem statement must be defined, sources of information (Appendices, etc.) must be identified, and an arrow must point to a single boxed solution. Illegible papers or those not adhering to the criteria established in ChE 317 will not be graded. Solutions to all problems must include adequate steps, and explanations where necessary, for us to understand how you arrived at an answer. Just an equation and a final answer will not be acceptable. The total homework score is worth 15 % of your overall course grade.

Grading Policies -- Homeworks, quizzes, and exams will be **approximately** graded according to the following:

5%	Participation (making any honest attempt)
15%	Accurately defining the problem (drawing a correct schematic/interpretation of the system)
40%	Setting up the problem (making accurate assumptions, defining the correct equations, adequately explaining all steps required to reach a solution, justifying your approach)
30%	Correctness and completeness (making accurate calculations, using correct conversions, using appropriate physical properties, identifying sources of information, accurately interpreting data from tables, carrying solution to completion, using correct significant figures)
10%	Neatness, organization (logical flow), and boxing final solutions

Problems should be worked in units that are consistent with the units given in the problem statement. The final solution must be reported in units consistent with those given in the problem statement. For example, if the problem statement gives metric units, do not report your solution in English units.

Note: Conceptual errors are weighted more heavily than simple mathematical (calculation) errors.

Late Assignments – No late assignments will be accepted without permission from Professor Poehl.

Grading Disputes -- Discussion on assignments should be initiated with the TA or grader, and only math errors and oversights will be considered valid reasons for dispute. If your work is not clear or the specific question involves subjectivity, then there is no justification for re-grading. Grades will not be discussed after one week from the date the assignment is returned.

Quizzes -- Quizzes will be **closed book** with required tables and figures supplied.

Exams --

Exams will be **open book and open notes**. A review session will be held prior to each exam.

Requests for re-grading must be submitted to the professor ***within 1 week*** after the graded exam has been returned. If re-grading is desired, then the entire exam is subject to re-grading. As with assignments, if your work is not clear or the specific question involves subjectivity, then there is no justification for re-grading.

Missed Exam -- No make-up exams will be given without a written excuse for the absence.

Final Exam -- The location will be announced later in the semester. The date and time of the exam cannot be changed, and there will be no make-up final. Registration for this course includes the university-scheduled final exam date.

Cheating -- Cheating is strictly forbidden and anyone found doing so will be turned over to the University and will be dealt with according to University policy. Working together on homework is encouraged, but each person must independently write-up his or her own work. Copying homework and photocopying graphs and figures between individuals is considered cheating. A **ZERO tolerance** policy will be applied, especially on exams.

Drop Policy– Registration changes after the official drop date require approval by the Department Chair and/or the Dean of Engineering.

Disabilities -- The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TTY or the College of Engineering Director of Students with Disabilities at 471-4321.

Exam I:
Macroscopic balances of fluid flow
Mechanical energy balance
Power law fluids and Bingham plastics
Sudden expansions, valves, and fittings
Flow metering
Pumps/pump selection and pump curves
Flow control
Branched flow networks

Exam II:
Flow past immersed objects
Packed and fluidized beds
Compressible flow principles
Compressors

Exam III:
Heat transfer principles
Conduction (conductivity) and convection (heat transfer coefficients)
Heat exchangers (concentric pipe, condensers, and shell & tube)
Fouling factors and extended surfaces
Radiation
Parallel mechanisms of heat transfer

Final:
All of the above

Class Calendar:

Date	Day	Lecture No.	Reading Assignment Covered in Lecture	Lecture Topic
8-25	W	1	Syllabus / class web site	Introduction to course objectives and policies
8-27	F	2	MSH Ch.2	Static fluid phenomena
8-30	M	3		Static fluid phenomena
9-1	W	4	MSH Ch.3-4	Basics of fluid flow
9-3	F	5	MSH Ch.5	Incompressible flow
9-7	**M**		**LABOR DAY HOLIDAY**	
9-8	W	6		Incompressible flow
9-10	F	7		Incompressible flow
9-13	M	8		Non-Newtonian fluid flow
9-15	W	9	MSH Ch.8	Transportation and metering of fluids
9-17	F	10		Flow Control and Control Valves {*valve video*}
9-20	M	11		Pumps and Pump Selection {*pump video*}
9-22	W	12		*Exam Review*
9-23	**Th**	**--**		**Exam I -- 7 - 9 pm, ECJ 1.202**
9-24	F	13	MSH Ch.6	Flow of Compressible Fluids – The Basics
9-27	M	14		Flow of Compressible Fluids
9-29	W	15		Flow of Compressible Fluids
10-1	F	16		Flow of Compressible Fluids
10-4	M	17		Compressors
10-6	W	18	MSH Ch. 7	Compressors
10-8	**F**		***NO CLASS***	***NO CLASS***
10-11	M	19		Flow Around Immersed Objects
10-13	W	20		Flow Around Immersed Objects
10-15	F	21	MSH Ch.8	Fixed and Fluidized Beds: Industrial Applications
10-18	M	22		Fixed and Fluidized Beds: Industrial Applications
10-20	W	23		*Exam Review*
10-22	F	24	CFD Handout	Computational Fluid Dynamics
10-25	M	25	MSH - 10	Heat Transfer Introduction
10-26	**Tu**	**--**		**Exam II -- 7 - 9 pm, CPE 2.218 & CPE 2.220**
10-27	W	26		Conductive heat Transfer
10-29	F	27	**Guest Lecturer – Kriti Kapoor**	**Aspen Plus demo**
11-1	M	28		Conductive Heat Transfer
11-3	W	29	**Tutorial during Class Time**	**Tour of Pickle Research Center**

11-5	F	30		Conductive Heat Transfer
11-8	M	31	MSH Ch.11 –	Conductive Heat Transfer
11-10	W	32	MSH Ch. 12	Convective Heat Transfer
11-12	F	33	MSH Ch. 13	Convective Heat Transfer
11-15	M	34	MSH Ch.15	Heat Exchanger Design
11-17	W	35		Heat Exchanger Design
11-19	F	36	MSH Ch.14	Radiation
11-22	M	37		Heat Exchanger & Cooling Tower Videos
11-24	W	38		*Exam # 3 Review, Special Day – 1950 !*
11-26	**F**		**THANKSGIVING HOLIDAY**	*Also 11-29 Monday -* ***<u>No Class</u> – Exam Review***
11-29	M		**No Class – Individual Exam Prep**	
12-1	W	39		Course Evaluation – Special Topics
11-30	**Tu**			**Exam III -- 7 - 9 pm, CPE 2.218 & CPE 2.220**
12-3	F	40		Final Exam Review
12-10	F	--		**FINAL EXAM Friday, Dec. 10**
		--		**9:00 a.m. – Noon –**

<u>Note:</u>As a result of unforeseen circumstances, it may be necessary to make changes to the course schedule. Students will be informed in class, and via e-mail, of any changes made to the lecture or assignment schedule. Students are responsible for any announced changes (i.e., absence from the class in which the announcement is made is not an excuse).